RBM Vector Control Working Group

Outdoor Malaria Transmission Work Stream

Progress on 2012 Work Plan – Marc Coosemans, Institute Tropical Medicine Antwerp, Belgium

The importance of outdoor transmission was outlined and progress in 2012 described:

1. 4th Outdoor Malaria Transmission Work Stream meeting was held for Mekong countries in Bangkok, 12-13th March 2012.
2. Literature review on outdoor transmission.
3. Development of guidelines on spatial repellents (WHOPES) 'Guidelines for efficacy testing of spatial repellents'.
4. Research project topical repellents as an added intervention in Cambodia: MalaResT.

The next meeting will be held in March 2013 at Mahidol University in Bangkok.

Discussion

Outdoor transmission has always occurred. While it complicates elimination, indoor control remains the most important intervention and should not be neglected. Outdoor transmission does not indicate LLIN failure but is a reflection of success of control programs with LLINs and IRS for having reduced or eliminated vectors responsible for indoor transmission. Nomads are an important affected by outdoor transmission (e.g. in the Sahel, in East Africa) and must be protected by measures in addition to LLINs and IRS.

Larval Source Management (LSM) may help reduce outdoor biting in some specific settings. There was also some discussion of the role of space spraying in controlling outdoor malaria transmission noting that it is sometime used in the control of Aedes-borne dengue and chikungunya. WHO guidelines state that space spraying does not have a role in malaria control. Even under optimal conditions there is a maximum of 20-30 minutes when insecticide will be airborne and efficacious and often flying vectors are not active during this period. There are serious limitations to this approach and it does not have a role as a routine malaria control intervention.

There are difficulties in measuring the entomological parameters of outdoor transmission. Human landing catch at present is the only robust measure, but research ethics committees are sometims reluctant to approve its use, especially where there are circulating arboviruses.
WHOPES guidelines for efficacy testing of spatial repellents will be published in February 2013 and subject for review subsequently.

5th Outdoor Malaria Transmission Work Stream Meeting
13.00-15.00, Wednesday 30th January 2013
Auditorium, IFRC, Geneva

Chairs: Marc Coosemans and Chusak Prasittisuk
Rapporteurs: Olivier Briët and Lucy Tusting

Outdoor transmission in Africa - Gerry Killeen, Ifakara Health Institute (IHI), Tanzania and LSTM, UK

Gerry Killeen presented work conducted in collaboration with Dan Msellemus, Isaac Namango, Katarina, Nicodem Govella and Heather Ferguson. Work has investigated biological coverage indicators for eliminating malaria transmission. Behavioural resilience to LLINs and IRS in Tanzanian *An. arabiensis* populations has also been investigated, by assessing the proportion of bites received indoors given local patterns of human behaviour. Recent work has also outlined target product profiles for protecting against outdoor malaria transmission.

Discussion

There was some discussion of the relative importance of individuals sleeping indoors and outdoors. Outdoor sleeping is an important consideration where indoor transmission has been controlled. The priority is high LLINs and IRS coverage. With appropriate interventions, models indicate that it would be possible to achieve *An. arabiensis* population reductions similar to those observed in *An. gambiae.*

Review of outdoor and early transmission - Marc Coosemans, Institute Tropical Medicine Antwerp, Belgium

A recent review of outdoor and early transmission by Durnez and Coosemans was outlined. The principle of residual transmission was introduced, followed by examples of outdoor biting in South East Asia and Uganda and early biting in east and west Cambodia, Eritrea, Vietnam and Uganda. The 'gap' in control methods existed prior to the scaling-up of vector control. However the effect of vector control measures may have been to shift the ratio of indoor biting and indoor resting, as in Burundi (Smits et al., 1995); to alter species compositions, as in Kenya (Bayoh et al., 2010); to produce a shift to outdoor and early biting, as in Tanzania (Russell et al., 2010); and to produce a shift to early biting, as in Papua new Guinea (Charlwood et al., 1987). Other effects of indoor vector control interventions include an increase in the length of the oviposition cycle, induced by disrupting feeding behaviour, deterrence of vectors by insecticides such as DDT, plasticity in host selection and selection for secondary vectors such as *An. barbirostris.*

Mechanisms for shifts are as follows:

- *Protective avoidance*: Behavioural plasticity in response to insecticide, unavailability of host. Trigger of gene expression of accumulated gene variants, phenotypically neutral in normal environment. e.g. excito-repellent effect.
- *Protective behaviour:* exophily, exophagy, zoophily, early biting resulting in a minimum contact with insecticides used indoors.

- *Behavioural resistance*: develops gradually under insecticide pressure resulting in selection for mutations and recombinations. This is difficult to demonstrate due to confounding factors such as environment changes.

In conclusion:

- Although current vector control tools (LLINs and IRS) are effective, they only tackle indoor and night biting, and indoor resting malaria vectors, leaving a gap in protection.
- Before the scaling-up of vector control, there was large heterogeneity in vector behaviour.
- With the scaling-up of vector control efforts, the importance of outdoor and early malaria transmission is increasing.
- Additional control tools are required for addressing this residual malaria transmission.

Discussion

Points raised during the discussion included the importance of distinguishing between differences in plasticity and genetic shifts in behaviour that has evolved and remains. True evolution is likely to be rare. It was highlighted that programmes should continuously assess human and vector behaviour. The efficacy of vector control in reducing *P. vivax* during the final stages of elimination was discussed. A hypothesis was formulated that saliva of uninfected anophelines may activate the hypnozoites.

Topical and spatial repellents - Sarah Moore, LSHTM, UK

The benefits to vectors of outdoor and early evening feeding when intra-domiciliary control tools are used were outlined and data illustrating differences in the ratio of indoor to outdoor biting were presented for South America and the Mekong region. Data from a recent meta-analysis of topical repellents was presented. Repellency was defined as a general term referring to a range of insect behaviours induced by chemicals that result in a reduction in human-vector contact, including: (1) movement away from a chemical stimulus, (2) interference with host detection (attraction-inhibition), (3) interference with feeding response and (4) incapacitation. Data for various spatial repellents including transfluthrin-treated hessian strips was presented.

Discussion

It was debated whether evidence of personal protection would count as sufficient epidemiological evidence or whether evidence of community protection must also be demonstrated. Interference of repellents with attract-and-kill tools should be considered, for example several topical trials have been conducted in combination with LLINs. Diversion is important for endophagic endophilic mosquitoes but not for zoophagic vectors. It was highlighted that there is a strong retail market for repellents. If proof of principle for spatial repellents, who will fund the development of new tools and will repellents compete with the funding for current tools? Costs could be reduced through subsidies where LLINs and IRS are not fully appropriate (for example, for particular risk groups such as forest workers and miners).

Personal protection tools from the deployed warfighter research program – Scott Gordon, Armed Forces Pest Management Board, USA

The views and opinions expressed in this presentation were solely those of the author. Mention of a trade name, product or company does not constitute endorsement by the US Department of Defense (DoD).

Current research efforts by the AFPMB Deployed Warfighter Research Program include: (1) permethrin-treated uniforms, (2) non-toxic insect resistant textiles, (3) mosquito attraction inhibitors, (4) new fast acting volatile pyrethroids, (5) functional micro-dispensers. The overall vision of the program is to recommend and exercise DoD policy, execute technical oversight, provide scientific advice and enhance coordination among the Military Services on all matters related to medical entomology and pest management and to ensure deployed combat forces have the most effective disease vector control and pest management capabilities to prevent adverse effects on troops, weapons systems, supplies and equipment, and installations using environmentally sound techniques with maximal risk reduction. The program is currently in its 9th year, with annual funding of US$5.1 million, with particular focus on (1) novel insecticide chemistries and formulations, (2) personal protective systems and (3) pesticide application technology, primarily targeting mosquitoes, sand flies and filth flies.

Current projects include the development of permethrin Treated Military Uniforms, Mosquito Attraction Inhibitors, New Fast Acting Pyrethroids, a Velcro wrist band with natural fiber matrix, Reverse Band-Aid, Functional Micro-Dispensers. Other work includes outdoor barrier treatment to reduce sand flies and mosquitoes (Dr Ken Linthicum, USDA CMAVE; Dr Alon Warburg, Hebrew University), enhancing the efficacy of pyrethroid insecticides against mosquitoes using plant essential oils and individual terpenoids (Dr Joel Coates, Iowa State University), development of a New Indoor Residual Spraying Formulation for Mosquito Control (Dr Mike Willis, Clarke), new safe carbamates (Dr Jeff Bloomquist, University of Florida), attractive targeted sugar baits for sand fly control (Dr Günter Müller, Hebrew University; Dr Amir Gallili, Westham Industries; Dr Laor Orshan, Israeli MoH) and molecular pesticide development (Dr Jimmy Bechnel, USDACMAVE; Dr Catherine Hill, Purdue University).

Discussion
WHOPES does not have guidelines for risk assessments for long-term exposure to permethrin-treated clothing, although industry and AFPMB do. Interventions such as these are appropriate for certain target groups, but not for the general population. It was queried whether there are any WHOPES plans to evaluate insecticide treated clothing in terms of personal protection. A risk assessment of permethrin treated clothes should be available before these products can be tested by WHOPES.

Actions and 2013 Work Plan

1. To explore the mechanism of a shift in species and behaviour of vectors (exophagic, early biting, exophilic, zoophilic) as a consequence of scaling-up vector control.
2. To collect further evidence on the epidemiological efficacy of topical, spatial repellents and protective clothing, and on personal versus community protection.
3. To develop standard designs to evaluate variation in time (biting time) and space (outdoor vs indoor) of malaria transmission.

4. To conduct a risk assessment of insecticide treated clothes.
5. To improve designs for the evaluation of the protective efficacy of repellents (topical and spatial, and both personal and community protection).
6. To conduct informative research to improve adherence to personal protective method.

The next meeting of the Work Stream is to be held in March (date TBC).

Participants

	Family name	Name	E-mail address
1	Abeyasinghe	Rabindra	rabindraabeyasinghe@gmail.com
2	Akle	Ziad	marketing@treated-bednet.com
3	Akogbeto	Martin	akogbetom@yahoo.fr
4	Allan	Richard	richard@mentor-initiative.net
5	Amajoh	Chioma	amajohc@yahoo.com
6	Aultman	Kathryn	kate.aultman@gatesfoundation.org
7	Babaley	Magali	babaleym@who.int
8	Besnier	Maxime	besnier.maxime@hotmail.fr
9	Bosselmann	Rune	rune.bosselmann@insectcontrol.net
10	Boutsika	Konstantina	konstantina.boutsika@unibas.ch
11	Briët	Olivier	olivier.briet@unibas.ch
12	Brown	Andrea	anbrown@jhuccp.org
13	Brown	Nicholas	nick@azpfl.com
14	Chang	Moh Seng	mohseng.chang@gmail.com
15	Chitnis	Nakul	Nakul.Chitnis@unibas.ch
16	Coetzee	Maureen	maureen.coetzee@wits.ac.za
17	Coosemans	Marc	mcoosemans@itg.be
18	DeChant	Peter	peter.dechant@valent.com
19	Dengela	Dereje	Dereje_Dengela@abtassoc.com
20	Diouf	Mamadou Lamine	mamadoulamine.diouf@pnlp.sn
21	Eves	Katie	katie@mentor-initaitive.net
22	Fornadel	Christen	cfornadel@usaid.gov
23	Fotheringham	Megan	mfotheringham@usaid.gov
24	Gimnig	John	hzg1@cdc.gov
25	Gordon	Scott	scott.gordon@osd.mil
26	Griffin	Haynes	haynesgriffin@insectshield.com
27	Griffin	Jason	jasongriffin@insectshield.com
28	Heimsch	Alexander	alexander.heimsch@basf.com
29	Hesse	Gerhard	gerhard.hesse@bayer.com
30	Hetzel	Manuel	manuel.hetzel@unibas.ch
31	Hoyer	Stefan	hoyers@who.int
32	Invest	John	john.invest@btinternet.com
33	Jany	William	wjany@clarke.com
34	Kilian	Albert	albert@trophealth.com
35	Killeen	Gerry	gkilleen@ihi.or.tz
36	Knowles	Steve	steve.knowles@AnglogoldAshanti.com
37	Knox	Tessa	tk@vestergaard-frandsen.com
38	Koenker	Hannah	hkoenker@jhuccp.org
39	Kolaczinski	Jan	jan.kolaczinski@theglobalfund.org
40	Konate	Lassana	konatela@yahoo.fr

41	Lindsay	Steve	s.w.lindsay@durham.ac.uk
42	Lines	Jo	Jo.Lines@lshtm.ac.uk
43	Lluberas	Manuel	lluberas@hdhudson.com
44	Lorenz	Lena	lena.m.lorenz@gmail.com
45	Lucas	John	jlucas@olyset.net
46	Lynch	Matthew	mlynch@jhuccp.org
47	Macdonald	Michael	macdonaldlm@who.int
48	Majambere	Silas	smajambere@ihi.or.tz
49	McLean	Tom	tom.mclean@ivcc.com
50	Meier	Maude	mcmeier@SCJ.COM
51	Milliner	John	jemilliner@gmail.com
52	Mnzava	Abraham	mnzavaa@who.int
53	Moonasar	Devanand	MoonaD@health.gov.za
54	Moore	Sarah	sarah.moore@lshtm.ac.uk
55	Mothobi	Tjipo	tmothobi@gbchealth.org
56	Mueller	Pie	pie.mueller@unibas.ch
57	Murugasampillay	Shiva	shivam@who.int
58	Mutagahywa	Joshua	jmutagahywa@nb.rti.org
59	Nakamura	Masatoshi	mnakamura8823@gmail.com
60	Newman	Robert	newmanr@who.int
61	Overgaard	Hans	hans.overgaard@umb.no
62	Pates Jamet	Helen	hpj@vestergaard-frandsen.com
63	Peat	Jason	jason.peat@ifrc.org
64	Peter	Rosemary Jane	rose.peter@arystalifesciences.com
65	Prasittisuk	Chusak	prasittisuk@hotmail.com
66	Raghavendra	Kamaraju	kamarajur2000@yahoo.com
67	Ranson	Hilary	hranson@liv.ac.uk
68	Rowland	Mark	mark.rowland@lshtm.ac.uk
69	Rutta	Gaudence Juma Japhari	jrutta@nb.rti.org
70	Rwakimari	John Bosco	rwakimari_jb@ugandairs.com
71	Seddon	Ron	rseddon@leasemaster.com.pg
72	Segbaya	Sylvester	ssegbaya@AngloGoldAshanti.com.gh
73	Selby	Richmond Ato	r.selby@malariaconsortium.org
74	Skovmand	Ole	ole.skovmand@insectcontrol.net
75	Sloss	Robert	Robert.sloss@liv.ac.uk
76	Streat	Elizabeth	e.streat@malariaconsortium.org
77	Sweeney	Kevin	Sweeney.kevin@epa.gov
78	Teuscher	Thomas	teuschert@who.int
79	Thomas	Matthew	mbt13@psu.edu
80	Van Erps	Jan	vanerpsj@who.int
81	Vontas	John	vontas@biology.uoc.gr
82	Warren	Chris	cwarren@jsi.com

83	Weinmueller	Egon	egon.weinmueller@basf.com
84	Williams	Jacob	jacobwilliams@rti.org
85	Wirtz	Robert	rwirtz@cdc.gov
86	Yadav	Rajpal Singh	yadavraj@who.int
87	Yukich	Josh	jyukich@tulane.edu
88	Zaim	Morteza	ZaimM@who.int
89	Zhao	Zhou	yorkool@treated-bednet.com

Agenda		
12:00 – 13:00	Lunch	
	Poster viewing	
13:00 – 13:05	Objectives and introductory remarks	
13:05 - 13:20	Outdoor and early transmission – an old issue for new approaches	Marc Coosemans
13:20 – 13:35	Outdoor malaria transmission in Africa	Gerry Killeen
13:35 – 13:50	Discussion	
13:50 – 14:05	Topical and spatial repellents: where are we?	Sarah Moore
14:05 – 14:20	Personal protection tools from the deployed warfighter research program	Scott W Gordon
14:20 – 14:40	Discussion	
14:40 – 14:50	Mekong Outdoor Malaria Transmission Network	Chusac Prasittisuk
14:50 – 15:00	2013 Workplan: Discussion	
15:00 – 15:30	Afternoon break / coffee and tea	
	Poster viewing	